

# Case Study 219

## Two-speed motors on ventilation fans



**Deben swimming pool**

### Case Study Objectives

To demonstrate energy savings which are achievable by using two-speed fan motors on the supply and extract fans of a ventilation system.

### Potential Users

Any users of ventilation plant with potential for periodic operation at a reduced duty eg where only day-time occupation is required, and reduced ventilation is acceptable at other times. Two-speed fan motors in air handling units could be suitable in a wide range of applications ie: sports halls; gym-

nasia; supermarkets; foodhalls; warehouses; concert halls; auditoria; single-shift factories and process plant etc.

### Investment Cost

£450 above the cost of a single-speed system when fitted during refurbishment. The two-speed option costs £2,080 in the case of retrofit installation.

### Savings Achieved

34,748 kWh/year (29%), worth £1,200/year (21%) at current prices.

### Payback Period

4.4 months (new or refurbished installation), 1.72 years (retrofit applications).

### Case Study Summary

In 1990 Suffolk Coastal District Council (SCDC) decided to refurbish Deben Swimming Pool in Woodbridge, Suffolk. Under the refurbishment programme the existing ventilation plant was replaced. The air handling units chosen are normally supplied with single-speed fans as standard, but two-speed fans are offered as an option.

Two-speed fans were selected because of their lower capital cost compared to electronic variable speed drives and the projected energy savings and reduced running costs.

### Host Organisation and Installation Designer

Suffolk Coastal District Council  
Melton Hill  
Woodbridge  
Suffolk  
IP12 1AU

### Equipment Supplier

Dantherm Ltd  
Hither Green  
Clevedon  
Avon  
BS21 6XT  
Tel No: 01275 876851  
Fax No: 01275 343086  
Mr R Harding

### Monitoring Organisation

NIFES Consulting Group  
Charringtons House North  
The Causeway  
Bishop's Stortford  
Herts, CM23 2ER  
Tel No: 01279 658412  
Fax No: 01279 757304  
Mr G Read

There may be other suppliers of similar energy efficient equipment in the market. Please consult your supply directories or contact ETSU who may be able to provide you with more details on request.



**ENERGY EFFICIENCY**

**“... presents a compelling argument for the wider application of two-speed fans”**

## The Ventilation System

The air handling units installed at Deben pool were designed to operate on a full fresh air basis, with no recirculation. Energy loss is minimised by incorporating an air/air cross-flow heat exchanger and a reversible cycle heat pump in the system.

Air is extracted from the pool hall via a duct mounted high in the hall with an outside exhaust passing through the cross-flow heat exchanger and heat pump coils en route. Fresh supply air is pre-heated by being passed across the heat exchanger and through a low temperature hot water heater battery before being discharged to the pool hall.

Supply and extraction duties are performed by two fixed-pitch centrifugal fans.

The motors used are a 4/8-pole tap wound design nominally rated at 6.5 kW and 1.5 kW at high and low speed respectively. Speed change between half and full speed is achieved by switching between 4-pole and 8-pole operation, in effect doubling or halving the motor and fan speed.

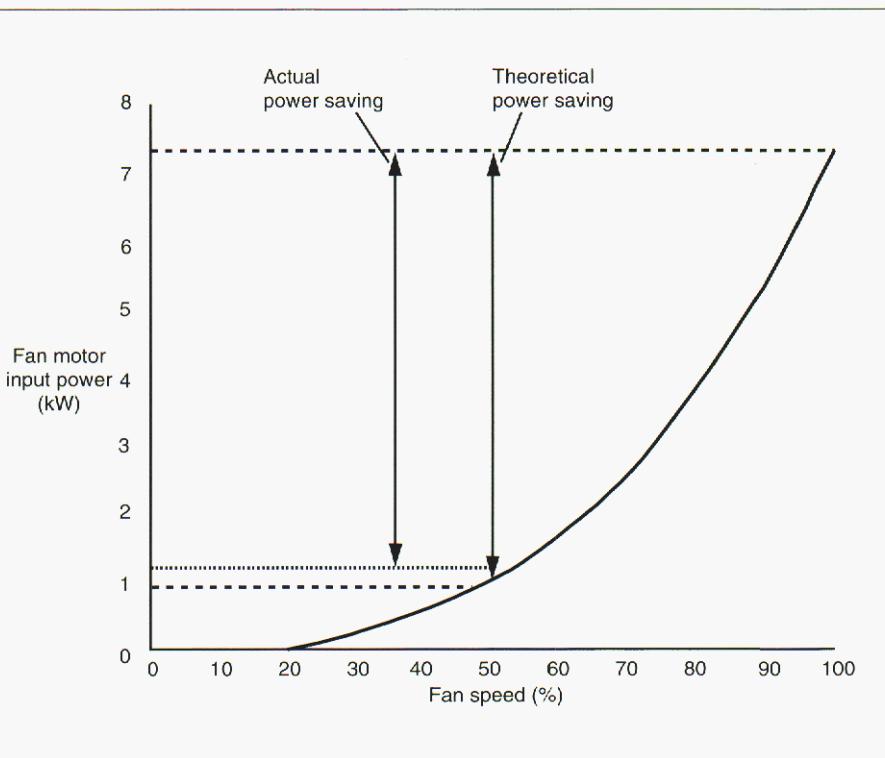
## Installation and Commissioning

There is no outward difference between air handling units with single-speed or two-speed fan motors. Installation is similar to that of an air handling unit of this design fitted with conventional, single-speed fan motors.

Control panels are supplied pre-wired by the unit manufacturer. Once sited they need only three-phase power connections and wiring to the fan motors. Fan motor connections are three-phase, six-wire, ie three wires per motor speed.

## Maintenance Requirements

Maintenance requirements are no different to those of a conventional, single-speed fan-equipped air handling unit. Once commissioned, performance can be expected to be similarly satisfactory.



**Power and energy consumption of two-speed fan**

## Operation

The air handling plant is operated continuously to remove humid air from the pool hall and replace it with warm, fresh air.

Speed changeover is controlled by a programmable timeswitch. The unit operates at full-speed between 06.30 and 22.30; and at half-speed for the remainder of the night. A humidistat, in the extract duct, overrides the time switch to return the fans to high-speed should the humidity rise above a pre-determined level during the night.

## The Fan Laws: Power Consumption versus Fan Speed

The power consumed by a fan is determined by one of the "Fan Laws" which

states that power consumption varies with the cube of the fan speed, while the flow rate varies proportionately to the speed. Reducing the fan speed by approximately a half will reduce the power consumed by the fan by 87%.

The above figure shows both the theoretical and actual savings. The actual saving is lower due to small decreases in the fan and motor efficiency for half-speed operation.

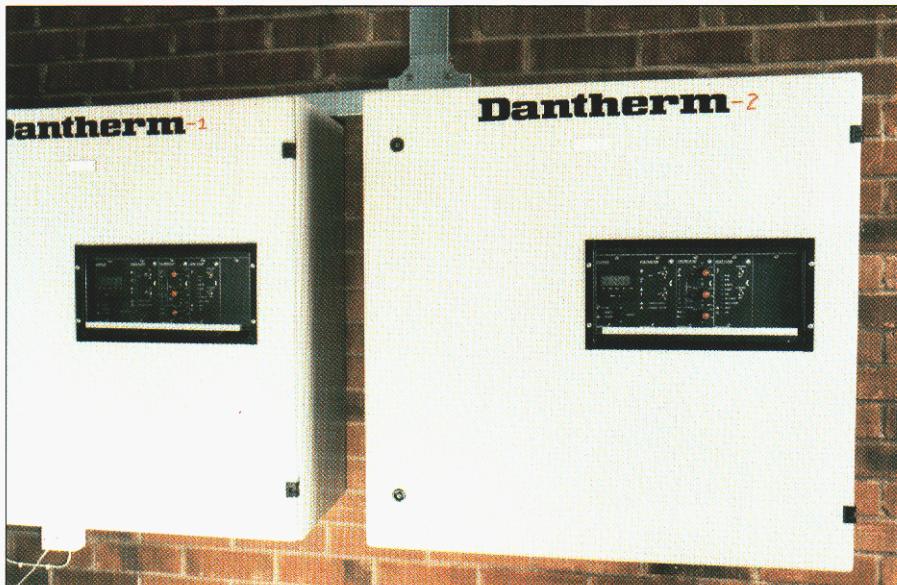
Where ventilation requirements can be reduced, eg overnight as in this example, savings are available in proportion to the power reduction and the time of operation at the reduced power. Additional savings in heating energy will occur in fresh air systems due to a reduction in exhausted warm air while the fans run at half-speed.

Automatic controls enable speed changes to be made easily on a fixed-time basis, some other variable (eg humidity), or a combination, as in this case.

## Energy Savings

Independently monitored data show that the actual power consumed by each motor in the two modes of operation was as follows:

- Supply fan motor, high speed: 7.3 kW
- Supply fan motor, low speed: 1.2 kW
- Extract fan motor, high speed: 6.1 kW
- Extract fan motor, low speed: 1.2 kW



**Air handling unit controllers**

The fans run at low speed for 8 hours/day. Thus the annual running hours for high and low speed operation are 5,840 hours and 2,920 hours respectively. Unit costs of electricity ruling at the time of the study were 5.79 p/kWh during the day, and 2.52 p/kWh overnight (7 hours from 24:00 to 07:00 winter and 01:00 to 08:00 summer).

Based on this information, the annual energy consumption for two-speed operation is calculated to be 85,264 kWh, at a cost of £4,600.

A single-speed equivalent would be fitted with supply and extract fan motors rated at 7.5 kW and 5.5 kW, consuming 7.9 kW and 5.8 kW respectively. The resulting annual consumption would be 120,012 kWh, costing £5,800.

The annual savings in energy consumption and cost are 34,748 kWh (29%) and £1,200 (21%) respectively.

#### Economic Analysis

The capital cost of a single air handling unit with two-speed fan motors was £16,600 (1993 price).

If a single-speed equivalent unit had been selected then the capital cost would have been £16,150 (1993 price).

Thus the extra over-cost of the two-speed motors is £450.

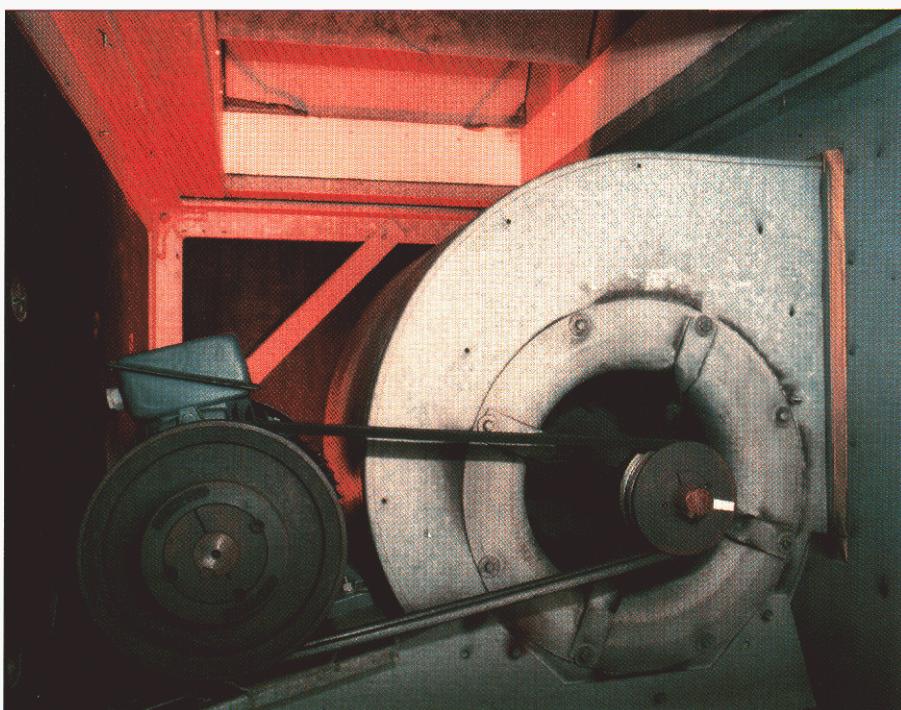
In many cases two-speed fan motors could be retro-fitted into existing air handling units. In this case the estimated cost of conversion would be £2,080, which can be broken down as follows:

Item	Cost £
Supply 2 x two-speed motors	840
Supply 2 x motor drives	
Modify control panel	
Wiring	1,240
Labour	
<b>Total</b>	<b>2,080</b>

#### Other Benefits

Additional benefits include:

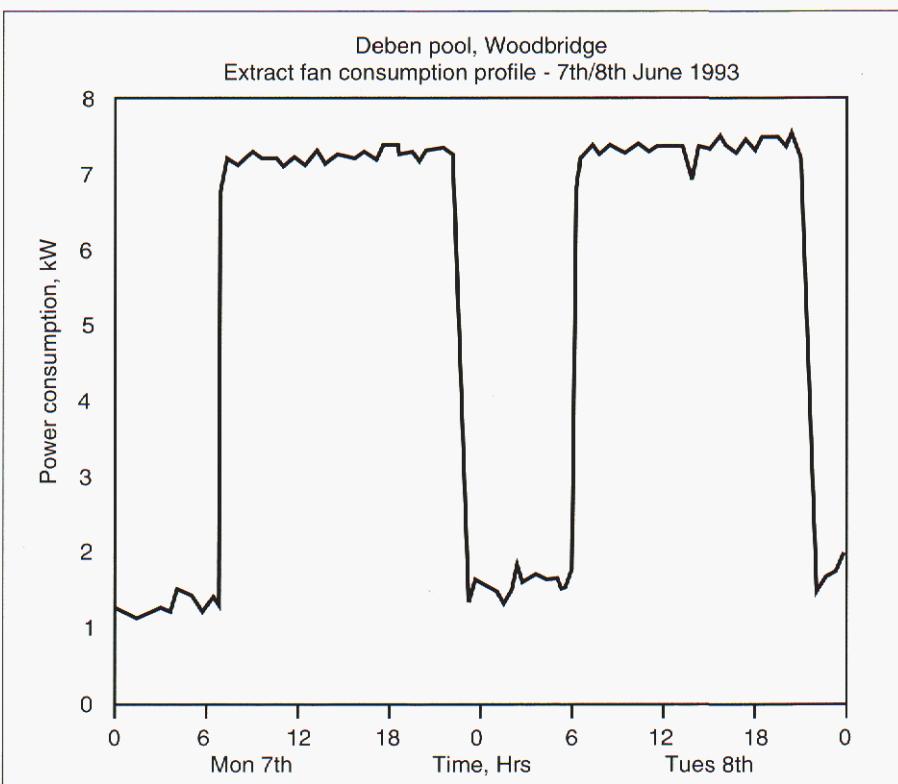
- reduced noise during low-speed operation. This could benefit industrial ventilation applications in residential areas.
- simplicity and low capital costs, compared to alternative methods of speed control, eg ac variable speed drives.
- reduced heating energy consumption and cost resulting from the lower air volume treated during night time operation.



**Two-speed motor and fan - in many cases such motors can be retro-fitted**

The economic analysis is summarised in the table:

	Capital Cost (£)	Running Cost (£/Year)	
Single Speed System	16,150	5,800	
	Additional Capital Cost (£)	Annual Savings (£/Year)	Simple Payback (Years)
Two-Speed System (New)	450	1,200	0.37
Two-Speed System (Retrofit)	2,080	1,200	1.72



**24 hour power consumption profile of the supply fan motor**

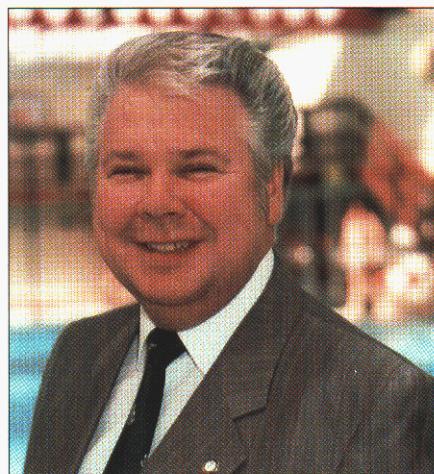
## Comments from Suffolk Coastal District Council

In 1990, Suffolk Coastal District Council decided to replace existing, aging and unsatisfactory ventilation plant at Deben pool.

Energy efficient operation was a prime consideration in our selection. The potential economic disadvantages of supplying 100% fresh air to the pool hall were offset by incorporating cross-flow heat exchangers and reverse-cycle heat pumps.

High efficiency motors and/or inverters were considered unnecessarily elaborate and expensive for this project, although the installation did appear to be ideally suited to the use of two-speed fans. These would be set up to run at full speed when the pool was in use and at half speed when it was not.

The substantial savings relative to the capital costs and the simplicity of operation made this an attractive measure, particularly when the additional savings from reducing overnight heat loads are considered. These advantages present a compelling argument for the wider application of two-speed fans.



**Deben swimming pool**

## Suffolk Coastal District Council

Suffolk Coastal District Council is situated in Woodbridge. The council serves several market towns and has rich agricultural countryside. The District covers 88,938 hectares (343 square miles), with a total population in excess of 115,000. Over the past eight years the council has reduced the energy consumption of its buildings by approximately 34%. The current energy bill amounts to approximately £0.4 million/ year.

L M Miller  
Building Services Engineer  
Suffolk Coastal District Council

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### Further information:

For buildings-related topics contact:

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**Good Practice:** promotes proven energy efficient techniques through Guides and Case Studies.

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**General Information:** describes concepts and approaches yet to be fully established as good practice.

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**Energy Efficiency in Buildings:** helps new energy managers understand the use and costs of heating, lighting etc.